ECOM-5064
July 1966

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ROCKET-BORNE OZONESONDE

By

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ECOM

UNITED STATES ARMY ELECTRONICS COMMAND

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DA PROJECT 1L013001A91A

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ACKNOWLEDGEMENT

I wish to acknowledge the help received from the staff of the Schellenger Research Laboratories, Texas Western College, El Paso, for the fabrication of the instrument.

ABSTRACT

A stratospheric ozonesonde has been developed which utilizes the chemiluminescent principle for the measurement of ozone concentration after deployment from an Arcas rocket vehicle. A sample bottle empties as it is carried to low pressures of high altitudes and is ejected above the stratopause level. Flow into the bottle results from the differential pressure as the instrument descends on a drag parachute. Ozone in the environment flows over the detector and the photons produced by the destruction of ozone molecules on the chemiluminescent material are monitored by a photomultiplier tube. The output signal is transmitted on a carrier frequency of 1680 megacycles and received at the ground by AN/GMD-1 equipment. The instrument is calibrated with known concentrations of ozone and flow rate. Results of one firing are presented.

CONTENTS

INTRODUCTION

It is well known that the vertical distribution of atmospheric ozone shows large variations with latitude, season and weather conditions. Ozone measurements had been made primarily with balloons using Paetzold and Piscalar (1961), Brewer and Milford (1960) and Regener (1960, 1964) instruments and by a few rocket probes (Johnson et al., 1952) using different types of solar spectrometers. These balloon-sondes do not reach the stratopause level of the atmosphere. Recently a rocket-borne ozonesonde (Randhawa, 1966), which utilized the chemiluminescent principle for ozone detection, was developed and fired with the Arcas rocket at White Sands Missile Range, New Mexico. A serious disadvantage of these earlier sondes was that they could not be fired during daylight because of contamination of the photomultiplier output by the stray light. There is a pressing need for an ozonesonde which can be deployed at any time of day or night.

INSTRUMENT

The rocket-borne ozonesonde (Figure 1), a "self-pumping" type, consists of three main parts: power supply, sample bottle including photomultiplier tube and chemiluminescent detector, and telemetry circuit. The photomultiplier tube and the associated high-voltage supply circuitry are potted in black silicone rubber and mounted inside the bottle as shown in Figure 2. The channel for the flow of the air into the bottle is made from teflon and provides two 90^{o} turns to eliminate the stray-light effect. The chemiluminescent detector is mounted across the photomultiplier tube. Ozone in the environment flows over the detector and the photons produced by the destruction of ozone molecules on the chemiluminescent material are monitored by the photomultiplier tube. The output signal is transmitted on a carrier frequency of 1680 megacycles and received at the ground by AN/GMD-1 equipment (Clark and McCoy, 1965).

The ozonesonde is deployed from an Arcas rocket vehicle above the stratopause level. The bottle empties itself as it is carried to low pressures of high altitudes. Flow into the bottle results from the differential pressure as the instrument descends on a 15-foot diameter radar-reflective parachute. The intensity of the emitted light is directly proportional to the ozone flux entering the detector. This flux is equal to the product of ozone concentration and the flow rate. Thus, in order to measure ozone concentration, the flow rate into the detector must be known. As the instrument falls (120 m sec^{-1} at 50 km and 30 m sec^{-1} at 30 km) through the atmosphere of increasing density, the pressure inside the bottle tends to equilibrate with the external pressure, thus leading to a net flow of air into the bottle through the inlet channel. This flow rate can be expressed as

$$\text{flow rate} = \frac{V_i T_a}{P_a T_i}\left[\frac{dP_i}{dt} - P_i \frac{d\ln T_i}{dt}\right]$$

where V_i = Bottle volume

T_i = Air temperature inside the bottle

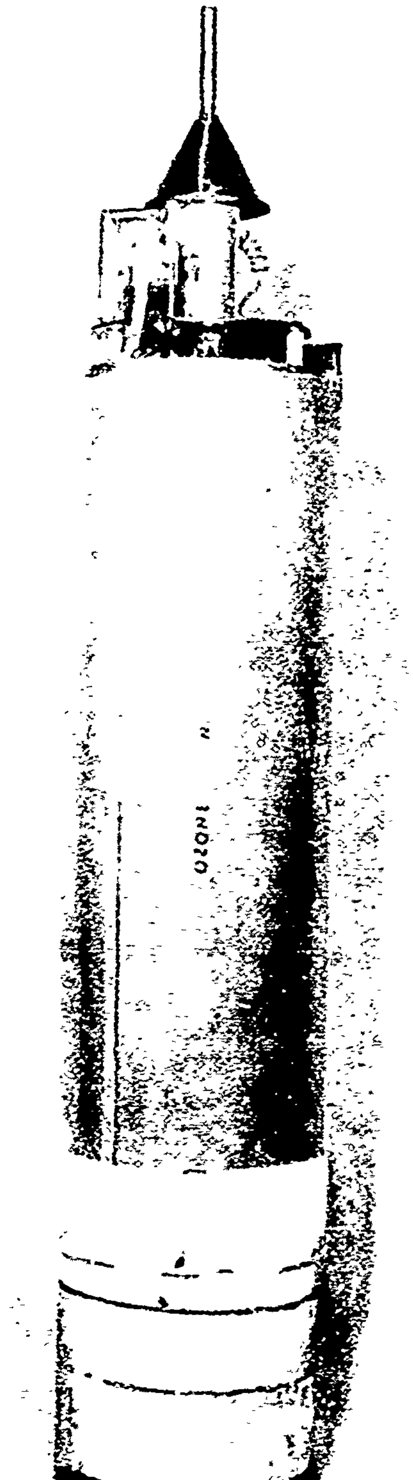

FIGURE 1. Rocket-Borne Ozonesonde.

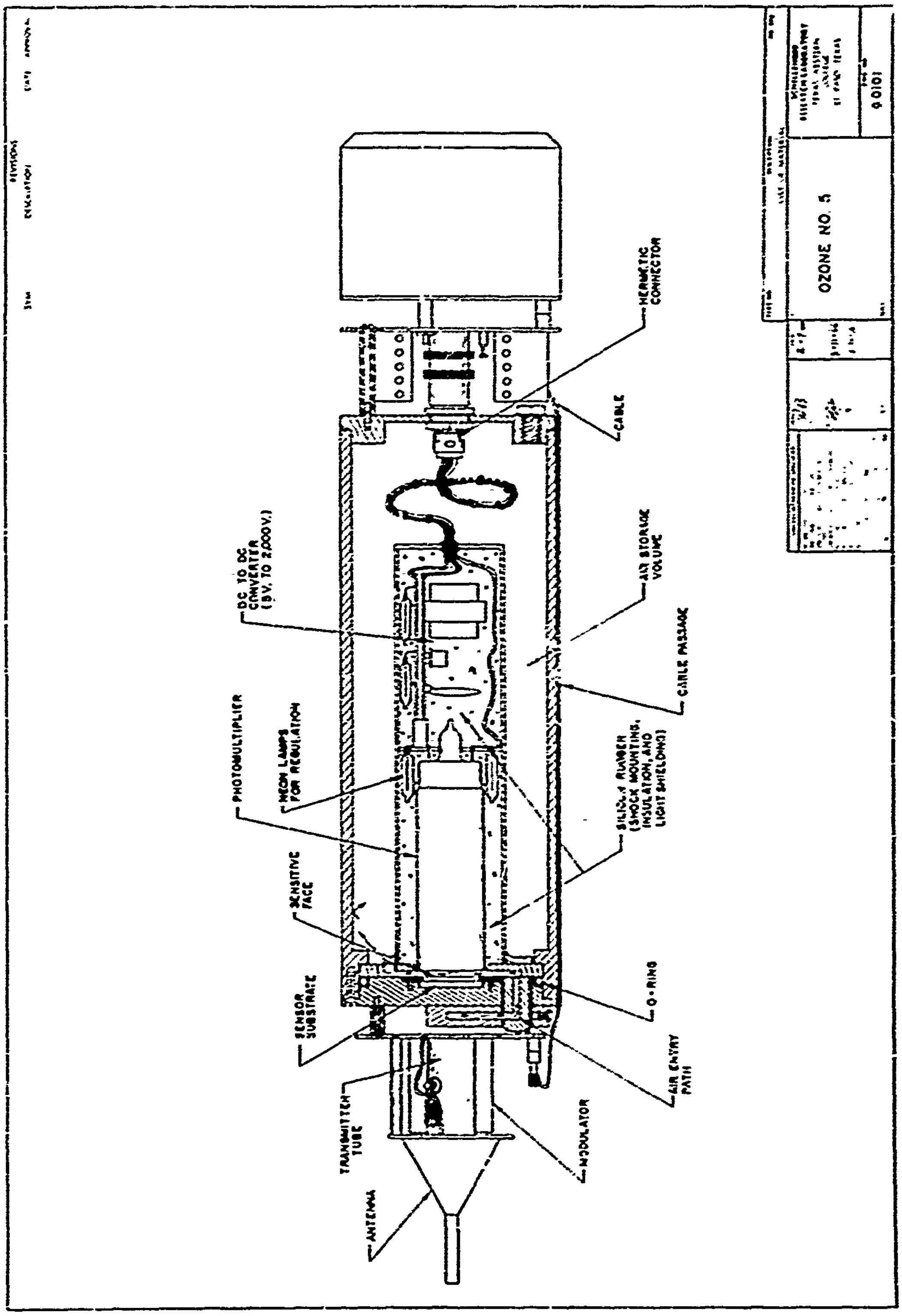

FIGURE 2. Schematic Diagram of Rocket-Borne Ozonesonde.

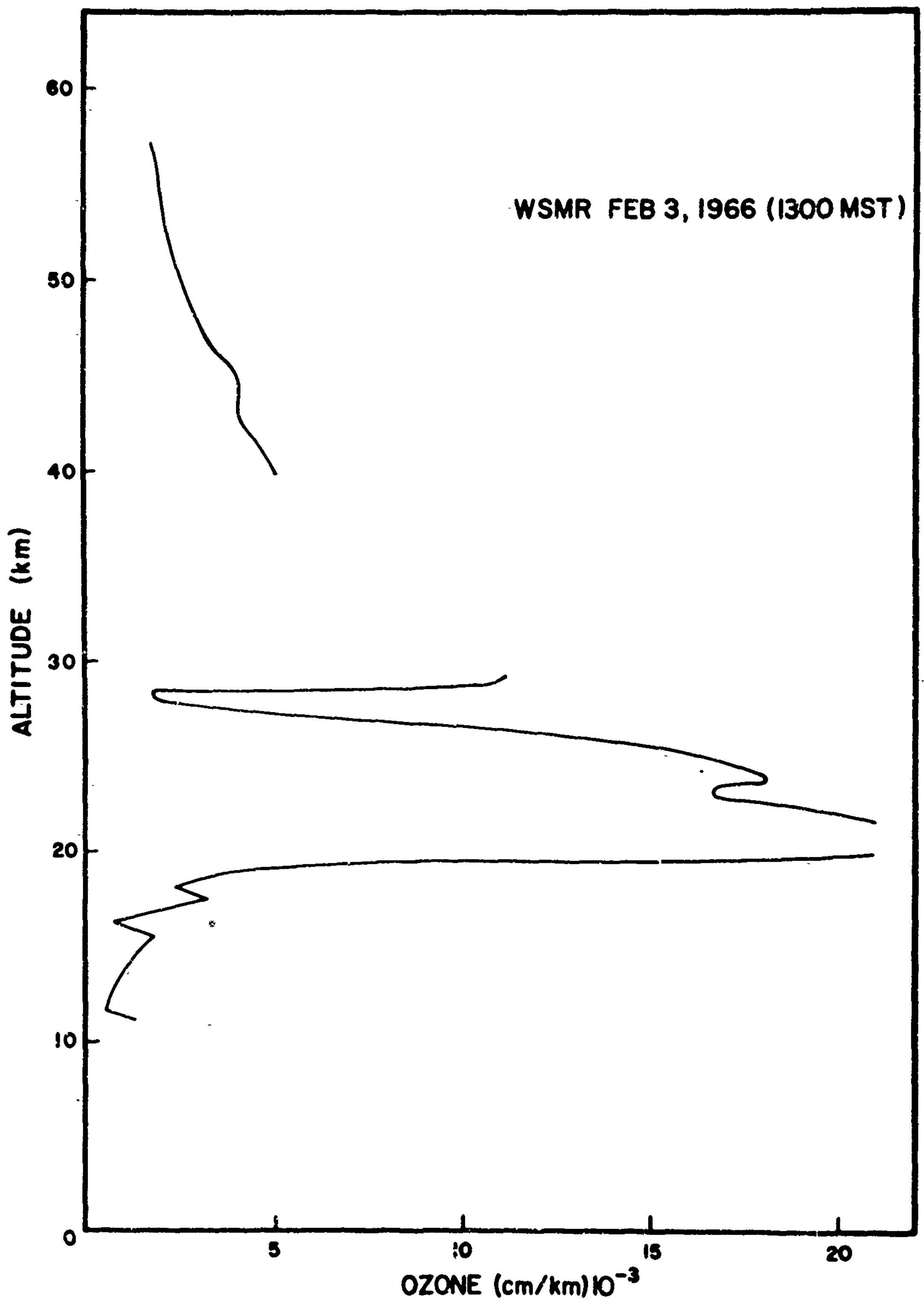

FIGURE 3. Ozone Distribution with Height.

P_i = Pressure inside the bottle

T_a = Ambient external temperature

P_a = Ambient external pressure

t = Time

This expression can be simplified considerably if one assumes $P_i \approx P_a$ and $T_i \approx T_a$ which is quite reasonable. As the instrument falls, the bottle will be cooled continuously during descent; therefore, the second term, which is one order of magnitude less than the first term, will always add to the flow rate.

The ozonesonde is calibrated before launch by the use of an ozone generator (Regener, 1964). Ozonized air of known concentration and flow rate is injected into the bottle and sensitivity is set in the proper range.

RESULTS

The rocket-borne ozonesonde was fired on February 3, 1966 at 1300 MST and deployed at 60 km altitude. The radar track of the parachute yielded altitude and fall rate vs time. As the payload (which weighs 3½ kg) descended on the parachute, ozone concentration was sampled continuously. The reduced data are presented in Figure 3, which shows a discontinuous profile because of high sensitivity setting. This profile clearly shows two peaks, one near 20 km and the other between 30 and 40 km and is in agreement with previously reported profiles (Randhawa, 1966) obtained with a different rocket-borne ozonesonde.

CONCLUSIONS

A rocket-borne ozonesonde, which incorporates a "self-pumping" feature and operates on the chemiluminescent principle, has monitored the atmospheric ozone concentration to higher altitudes than had been possible by earlier methods. The system is capable of providing information on the detailed structure of the upper stratosphere and is thus considered suitable for synoptic observations in the Meteorological Rocket Network.

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Electronics Command Ft. Monmouth, New Jersey	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

ROCKET-BORNE OZONESONDE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Randhawa, Jagir S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1966	7	7

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. DA 1L013C01A91A	ECOM - 5064
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this report is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Electronics Command Atmospheric Sciences Laboratory White Sands Missile Range, New Mexico

13. ABSTRACT

A stratospheric ozonesonde ~~has been~~ was developed which utilizes the chemiluminescent principle for the measurement of ozone concentration after deployment from an Arcas rocket vehicle. A sample bottle empties as it is carried to low pressures of high altitudes and is ejected above the stratopause level. Flow into the bottle results from the differential pressure as the instrument descends on a drag parachute. Ozone in the environment flows over the detector and the photons produced by the destruction of ozone molecules on the chemiluminescent material are monitored by a photomultiplier tube. The output signal is transmitted on a carrier frequency of 1680 megacycles and received at the ground by AN/GMD-1 equipment. The instrument is calibrated with known concentrations of ozone and flow rate. Results of one firing are presented.

DD FORM 1 JAN 64 1473

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
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